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Living Lab Approach For Developing Massmarket IoT Products And Services

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Abstract: Internet of Things (IoT) has emerged as a central concept in both the industrial as in the academic world. In this context, Living Lab research has been shown as an effective means for the design, implementation, development, testing and validation of Internet of Things system's pervasiveness. However, IoT products are not yet designed based on the needs of a larger, non-technical group of end-users. Therefore, in this paper we describe the AllThingsTalk Living Lab research track in which tangible end-user products are defined to be implemented on an online IoT platform. More specifically, by using both qualitative and quantitative methodologies (*i.e.,* desk research, online survey, probe research and co-creation) and by selecting different types of users (*i.e.,* based on Rogers' adoption profiles) for these interaction moments, we were able to combine the input of these users to define tangible products that meet the needs of a heterogeneous group of end-users.

Keywords: Living Lab; Internet of Things; User involvement; Multi-method approach; online survey; probe research; co-creation

1 Linking up to the Internet of Things

In an era of interconnected, multi-device and cross-platform products and services, the Internet of Things (IoT) has emerged as a central concept. Although some refer to it as just another buzzword, it cannot be ignored that in the past years the attention for Internet of Things has increased tremendously in both the industrial and in the academic world. With more 'things' connected to the internet than there are people in the world, and even more to be connected in the near future, Cisco is even talking about the Internet of Everything (IoE) (Cisco, 2013). IoE will make networked connections more relevant and valuable by bringing together people, processes, data and things. In this regard, Gartner states that personal worlds and the Internet of Everything (IoE) are colliding to create new markets. By 2020, a predicted number of over 30 billion connected devices will be in use, creating $1.9 Trillion of economic added value (Gartner, 2013).

We can define two types of IoT systems. On the one hand, there are Latent IoT systems that are nowadays becoming vastly embedded in our society (*e.g.,* planes communicating to the airport control tower, automatic data synchronization between

mobile phones via the cloud,…). On the other hand, there are Manifest IoT systems that are more visible and tangible to the user and are to this day less embedded in our society (*e.g.,* self- learning Thermostat NEST, SmartThings' home security systems controlled remotely by the smartphone, wearable tracking bracelets that logs the users' movements troughout the day,…). Currently, Manifest IoT systems are particularly appealing to crowd niches (e.g. developers, DIY'ers, maker movement,…).

We witness that these Manifest IoT products are not developed and marketed to appeal to a large audience. Since these systems often require programming language to configure all the settings, current users are most likely to be highly skilled computer experts such as IT-specialists, developers and DIY'ers (Diana, 2013). In order to trigger widespread user adoption for these manifest IoT systems, we believe it should be developed based on the needs and wants of rather low-skilled users. In other words, there is a need for a user-centric approach taking into account different types of users.

Therefore, in this paper we will focus on Manifest IoT-based products and services. More specifically, we will describe a Living Lab research track in which an open-source Internet of Things platform is developed aiming at large-scale end-user adoption. By using an interplay of both qualitative and quantitative methods, we will try to bridge the gap between developers of Manifest IoT systems and a large group of end-users.

The goal of this paper is to show how Living Lab research can provide a solution for the development of user-centered mass market IoT products and services and subsequently bridge the gap between manufacturers and end-users. More concretely, we show how the involvement of different types of potential users of the IoT platform in different stages of the Living Lab research track can be beneficial to the final product.

2 Literature

At first glance, we can determine that very few research has been conducted on Internet of Things from an end-user's point of view. However, some authors mention the significance of end-user empowerment and see an added value of a Living Lab approach in the development of these new products and services.

Michahelles (2009) for example predicts that the rise of IoT will follow the same patterns as the rise of the Internet in the late 90's and early 2000's. Therefore, he sees user empowerment as one of the key triggers for the Internet of Things to become widely adopted by end-users. Further, user-centered design methodologies such as participatory design, open-source development, end-user programming, crowdsourcing and living labs as innovation platforms are put forward. This way, end-users can be empowered with new building blocks and tools, similar to those that were emerging during the early phases of Internet growth (Cvijikj & Michahelles, 2011).

In order to obtain innovative ideas for new products von Hippel (1986) suggests to adopt concepts and prototypes already developed by users. This method, specifically designed, tested, and successful in industrial markets, has its drawbacks when applied to consumer markets with millions of users. Therefore, Franke (2003) suggest that monitoring some innovative user-communities may be an efficient method for identifying commercially appealing innovations made by users.

As for a Living Lab approach of IoT products and services, Vicini, Sanna and Bellini (2012) state that "Living Labs are the most natural and effective means for the design, implementation, development, testing and validation of an Internet of Things system's

pervasiveness". Moreover, "[…] the assessment of the user experience through the use of a Living Lab methodology […] is expected to dramatically increase the adoption of Internet of Things".

To structure and facilitate user involvement in the context of Living Labs for ICT and media innovation, an application of the lead-user framework looks promising (Schuurman & De Marez, 2012). This two-dimensional framework distinguishes between innovation for, with and by users and between evaluative and exploratory user involvement. It identifies six types of user involvement: market research, co-shaping, user toolkits, ideation, co-design and user innovation (Schuurman, Baccarne & Mechant, 2013).

Finally, in the context of user innovation in the IoT, understanding why DIY'ers and developpers would contribute to the services has been defined as one of the main challenges (Kortuem & Kawsar, 2010).

In this paper, we describe the Living Lab research case of AllThingsTalk (ATT). The start-up company AllThingsTalk wants to develop an open and cloud-connected Internet of Things platform that enables Smart Living Solutions for end-users, DIY'ers and developers. The ATT platform can provide solutions for and have a major impact on several domains of the Smart Living paradigm such as home entertainment and security, health care, family management and energy monitoring. In order to persuade the end-user of this platform (*i.e.*, to show the added-value of this online platform, *what's in it for the user?*), AllThingsTalk needs to develop tangible products that can be connected to the online platform. Therefore, a multi-method approach investigating users' needs and wants was applied, aiming at the development of concrete use-cases. This Living Lab research track consists of several interaction moments with end-users.

3 Living Lab research track

The earliest phase in which a user can be engaged in the innovation process is when generating innovative ideas in order to develop new concepts. In the AllThingsTalk Living Lab-project, the company involved is looking for practical use-cases for a home consumer market that show the added value of their Internet of Things platform.

The project started off with an extended desk research in which a state of the art focussing on current understandings on IoT from an end-user point-of-view was made. During this environmental scan, insights were collected on current and future trends, competitors and academic literature was thoroughly investigated. The goal of this is to provide a deeper understanding of the current evolutions, trends, knowledge and similar initiatives towards the research subject.

Next, in an ideation workshop a mass amount of ideas were being generated by 45 student participants with an interest in new media and ICT, but without a deep technological knowledge. The participants were asked to generate ideas on the statement: what would you use IoT for in you daily life? These ideas serve as a first indication of general user needs and wants, and of potential innovative ideas for the later use-cases.

These ideas were assessed on a larger scale in an online pre-survey (N=234), which also investigated the general habits and practices as well as the users' attitudes towards the innovation under investigation. The pre-survey also served as a means to divide the respondents in adoption profiles according to Rogers (2010) and to call for participation in the following interaction moments. In total 234 respondents, with a mean age of 41

years (S.D.=12.86) and 25% of which are female, completed the entire survey. The participants were recruited from the iMinds panel and additional sampling in dedicated LinkedIn groups.

Subsequently, in order to turn the selected ideas from the previous research steps into more concrete user scenarios, a probe research (N=15) was set-up. This deals with a heterogeneous set of users, selected from the survey respondents based on their innovation-related characteristics, that are engaged in practical and creative assignments regarding the ideas. They are forced to turn these ideas into more concrete user scenarios and use-cases and to give creative input to further shape and delineate them. In the probe research, we focussed on the following aspects:

- What are the existing routines of people in their home environment? (processes, situations)
- How do people adjust their lives and home environment to the limitations they currently experience? (experiences, frustrations)
- What adjustments would people like to do to improve their home environments? (Quality of Life)

Each assignment was accompanied with a clear explanation of the task and creative material (*e.g.*, pencils, markers, stickers, photo's,…).We encouraged the participants to complete the following 6 assignments during the course of one week.

- Make a floor plan of your house.
- Track on the map where you have been today.
- How could you day look like if IoT were ubiquitous?
- What thing would you like to be connected with now?
- Indicate on the map which things you want to control remotely.
- Choose 5 devices you want to be connected with. What would be the advantages? What are your current frustrations?...

Once these concepts have been shaped, the outcomes of the probe research were brought back to a wider community of potential consumers by organizing 3 co-creation sessions (each with 8 participants). Here the users within the Living Lab can contribute to the development of the product prototype. This is a four phases-process: discussion, conceptualization, evaluation and analysis. During these 3 sessions, participants composed If-Then-Else scenarios to be implemented in the online ATT platform. Also, product specifications of the Smart Living Kits were discussed, in-depth insights on privacy, security and data logging were collected.

In the end, this series of research activities has led to four very specific use cases and proof-of-concepts, called Smart Living Solutions, that will be further tested and validated in the Living Lab setting (*i.e.*, the platform and products will be demonstrated on a showcasing event and validated in an online post-survey).

4 Selection of different types of users

Since the goal of AllThingsTalk is to develop an IoT product that appeals to a large audience and not only a niche group of DIY'ers and developers, we decided to collect user insights from different types of users. A mix of both qualitative and quantitative methods and a selection of different types of users in different steps of the Living Lab research track should help with the elaboration of the ATT concept to concrete and tactile products (*i.e.,* the Smart Living Kits).

In the online pre-survey, we assessed the participants' willingness to use the ATT platform and their natural adoption potential of the platform using several Likert statements. This allowed us to cluster the respondents in different adoption profiles (Rogers, 2010). Based on these clusters, and on the intention of the respondents to contribute to interaction moments and to the platform (*i.e.,* test or develop the final product), we selected participants for further interaction moments of the Living Lab.

For the probe research, we chose for a mix of adoption profiles and consumers/contributors. For the co-creation sessions, we decided to organize three separate sessions in order to have homogenous groups. We first organized a session with high-skilled expert-users (*i.e.,* DIY'ers, developers, home automation owners) that were very enthousiastic towards the ATT platform. This was followed by a session with low-skilled users (*i.e.,* low computer knowledge and with a more wait-and-see attitude towards ATT). The outcomes of these two sessions were subsequently merged and discussed in a session with high- and low-skilled users. The goal of this last session was to compromise the visions of different types of users and to translate this into the four proof-of-concepts of the Smart Living Kits.

In the table below, an overview of user profiles, specific user characteristics and output of each research step is shown.

Table 1 Overview of user profiles, specific user characteristics and output of each research step

Research step	*N*	*User profiles*	*Specific user characteristics*	*Output research step*
Desk research	-	-	-	- Insights on IoT from end-user point-of-view
Ideation workshop	45	-	Interest in New Media and ICT	- User needs and wants - Ideas for use cases
Pre-survey	234	-	Interest in innovation research and IoT	- Experiences towards IoT - Expectations towards ATT - User profiles - Call for participation
Probe research	15	4 Innovators 3 Early Adopters 5 Early Majority 3 Late Majority	Mix of potential consumers and contributors	- Concrete user scenarios - Insights on potential of IoT in the home

Co-creation sessions	8	4 Innovators 4 Early Adopters	Potential contributors (enthousiastic towards ATT)	- If-Then-Else scenarios to be implemented on the ATT platform
	8	2 Early Adopters 6 Early Majority	Potential consumers (wait-and-see attitude towards ATT)	- Product specifications - Indepth insights on privacy and security
	8	2 Early Adopters 2 Early Majority 2 Late Majority 2 Laggards	Mix of potential consumers and contributors (wait-and-see attitude towards ATT)	- 4 proof-of-concepts of Smart Living Kits

5 From concept to product: development of Smart Living Kits

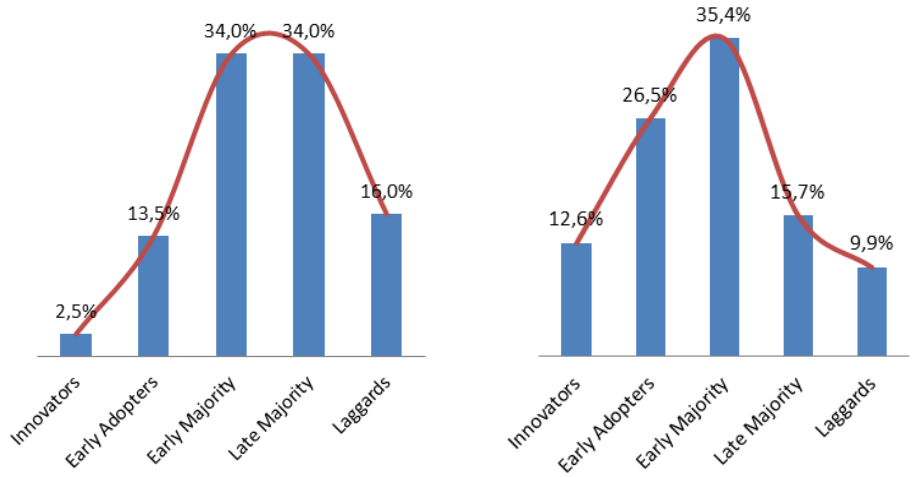
At the beginning of the AllThingsTalk Living Lab research track, the instigator had in mind the idea of an online platform on which several smart devices could be connected and be controlled based on easy to define settings. Although the platform itself promised to be a breakthrough in recent IoT developments, there was very few information available on the needs and wants of the end-users. Stated differently, AllThingsTalk had the platform, but they did not know how the end-user could benefit from it. AllThingsTalk therefore decided to start up a Living Lab research in which these dimensions should become clear with the final goal to make the online platform usable for the end-user.

The outcomes of the first five research steps (see Table 1), both qualitative and quantitative, were used to create four concrete use cases also called Smart Living Kits. These Smart Living Kits basically contain a network gateway, an Arduino and several sensors and smart devices according to the type of kit. By triangulating these 5 methods and enabling interaction between (different types of) potential end-users, developers and DIY'ers, we want to come up with successful use cases for the ATT-platform. Therefore, we focus on three types of user innovation:

- Innovation for users: assessing user attitudes towards IoT and the AllThingsTalk platform in the pre-survey
- Innovation with users: defining user scenarios during the probe research and shaping use cases during co-creation sessions
- Innovation by users: empowering users and encouraging users to be creative and put forward ideas during the mass ideation workshop, to be innovate during co-creation sessions

In the pre-survey, we saw that 64% of the respondents know what IoT is and 21% of them uses a product or service that is IoT-connected. According to the respondents, important features of IoT products and services are time saving, a central system that allows for control of devices from a distance, a system that works for the first time, a clear and transparent privacy policy and a central system that allows for automation of devices. When presenting the ATT platform, only 6% indicated that they would not contribute to the platform, 46% saw himself as a potential consumer and 48% sees himself as a potential contributor/consumer (*i.e.*, willing to test the platform or write/develop scenarios). In Figure 1. we see the diffusion of adoption profiles in Rogers'

normal distribution (a) and the one of AllThingsTalk (b). We believe that the amount of innovators and early adopters is higher in (b) because we recruited the respondents from a panel of people who are interested in innovation research.



(a) (b)

Figure 1 Adoption profiles according to Rogers (a) and the AllThingsTalk platform (b).

During the probe research, 15 participants were asked to complete 6 assignments over a period of one week. We noticed that the early and late majority profiles provided more basic ideas and scenarios, while the ideas and scenarios of the innovator and early adopter profiles (also more developers and DIY'ers) were much more profound. Combining these outputs of different types of end-users, developers and DIY'ers has led to scenario's that are workable and understandable for all users of the co-creation sessions.

Based on the outcomes of the ideation workshop, the pre-survey and the probe research, and in consultation with the instigator, four Smart Living Kits were defined:

- Comfort kit
  - Description: Make your home smart with the 'Comfort Kit', whether you're leaving or arriving, relaxing or working allow things to react to you or anything else you can think of
  - Contains: Gateway, smart wall plugs, LED colour controller
- Energy saving kit
  - Description: The 'Energy Saving Kit' makes conventional heating systems smarter. Replacing time based thermostats with a smart system can analyse when the temperature should be raised or lowered, based on your presence, preferences and activities
  - Contains: Gateway, smart thermostat, temperature sensor, smart radio controller

- Protection kit:
  - Description: The 'Home protection kit' turns your home into a safe place. Warning you of water leaks, smoke detection and abnormal activities whether you're at home or not
  - Contains: Gateway, flood sensor, smoke sensor, smart motion sensor
- Maker kit
  - The 'Maker Kit' is for the McGyvers among us. You can build your own projects easily and secure. You just have to use your imagination and you will be surprised what you can achieve.
  - Contains: Gateway, Arduino, cloud application subscription, client library, set of sensors

The scenarios that came out the probe research were subsequently transformed in the three co-creation sessions to If-Then-Else scenarios to be implemented on the ATT platform(*e.g.*, If: light intensity on sensor is less than 300 lux; Then: lamp on desk is on; Else: lamp on desk is not on). Also the four proof-of-concepts of Smart Living Kits were presented during these sessions and participants gave feedback on the product specifications.

According to the participants, the most favourite Smart Living Kit would be the Energy saving kit because it offers both comfort and saves money. This was most prevalent in the session with low-skilled users and in the mixed session. In the high-skilled session, there was no most favourite kit, but the different kits were found equally interesting. This was also seen as a positive aspect, since it's good to differentiate between different user groups. Non-adoption determinants of these kits are the risk of hackers (*e.i.*,fear of privacy breach) and the price of the kits, this will be researched in further steps of the Living Lab. The participants had no clear idea on how much they would be willing to pay for each kit. As for logging of data via the online platform, the overall opinion is that data can be logged, preferably not for commercial purposes and the user has to be aware which data is logged, what it is used for and the user should be able to decide whether data would be logged or not. Most participants agree to let their data be logged in the case they get a personal advantage for it (*e.g.*, discount on online purchases). The feedback on the online platform and the Smart Living Kits were mostly positive and most of the participants would use them. However, there should be more attention for a *fun* perspective in the kits. Also, the kits should be usable for low-skilled users as well (*i.e.*, clear instructions and easy to use).

6 Discussion

By applying different levels of user involvement, we profit from a user-based, bottom-up, qualitative approach for the development of future IoT products and services.

In this paper, we underline the added value of the implementation of a user-centric Living Lab approach in the development of an online IoT platform. This explorative approach provides evidence of the beneficial nature of customer involvement in product development and adds insights to the scarcity of research into specific user characteristics for innovation, and in extension Living Labs.

The instigator of the Living Lab, AllThingsTalk, also benefited tremendously from the research track because it helped them to define the final outlines of their IoT product. In the beginning, AllThingsTalk only had in mind the concept of the online platform and had no idea on how to translate this into tangible products (*i.e.*, the Smart Living Kits). By involving different types of users in different interaction moments, we were able to develop an IoT products that fits the needs of a large group of users.

By applying a multi-method approach and activating different types of users, we are able to detect the needs and wants of a relatively small user panel. This can be split up in two strategies. On the one hand, by relying on different types of users, we try to come up with a product that is representative to the needs and wants of a larger group of users. On the other hand, by transforming the creative ideas of these users to workable features of the IoT platform, we helped develop a new IoT product that is appealing to the mass market. In this regard, Living Labs can once again be seen as a means to bring technological innovations closer to a large group of end-users.

We see three groups of stakeholders in this process: manufacturers, end-users and researchers. The Living Lab approach in the AllThingsTalk-case can be seen as a way to opening doors between these manufacturers and end-users. Opening doors for manufacturers implies enabling them to bring user-centered IoT products and services to the end-user. Opening doors for end-users implies having a clear impact on the development process of future IoT products and services. In this interactive process, the researcher can be seen as a gatekeeper who has the responsibility to use the most appropriate research method and as a mediator who has to decide which information should be communicated between, from and to the manufacturers and the end-users.

The following steps of the Living Lab research track will be a showcasing event where the smart living kits will be demonstrated to the participants of the previous research steps. Next, a post-survey will be conducted in which the final product, the smart living kits, will be evaluated and fine-tuned by a large user panel and finally, a business modelling workshop with relevant stakeholders will be held in order to gain insights on business strategies.

7 Conclusion

The Living Lab research track presented in this paper shows the added value of the implementation of a user-centric Living Lab approach in the development of an online IoT platform. We started off with a large group of users to generate ideas on IoT in a ideation workshop, followed by a large-scale validation of the ATT platform in an online pre-survey in which also insights were gathered on IoT. The output of these steps was subsequently used in a probe research aiming at defining scenarios. Based on the three previous steps and in consultation with the instigator, four Smart Living Kits were defined. These proof-of-concepts were then presented and discussed in three co-creation sessions and the participants were asked to define If-Then-Else scenarios to be implemented on the ATT platform. The sequential flow of both qualitative and quantitative research steps will allow us to transform the concept of an online platform into a tangible product that appeals to the needs and wants of a larger group of end-users.

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